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How to identify larvae of the protected species: *Dioszeghyana schmidtii* (Diószeghy 1935), and survey its presence and abundance (Lepidoptera: Noctuidae; Hadeninae)

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ABSTRACT: *Dioszeghyana schmidtii* (Diószeghy 1935), is forest species protected by European Union. Its distribution has been studied essentially by the use of light traps. However, its biology and habitat preferences are not sufficiently known and thus its habitats may be damaged by forest management. We suggest the beating method in order to collect larvae as an useful way to record and to survey *D. schmidtii*. Larvae of the species can be collected by beating branches of its host plants (*Quercus* and *Acer* species) in the lower canopy (below 3 m). Optimal survey time would be the second half of May and the first half of June. Differences between the larvae of *D. schmidtii* and 16 similar moth larvae, as well as, Tenthredinidae (Hymenoptera) species living at the same time on the same trees are described and figured in a key to identification. The method described in the paper allows one to identify larvae in the field. Results are discussed.

Keywords: beating method; *Dioszeghyana schmidtii*; Habitats Directive 92/43/EEC; larvae identification; Lepidoptera

The Council of the European Communities has adopted the Directive 92/43/EEC (http://europa.eu/scadplus/leg/en/lvb/l28076.htm) 21 May 1992 (Habitats Directive 92/43/EEC) on the conservation of natural habitats, and of wild fauna and flora. One of the goals of the directive is to maintain or restore, at favourable conservation status, fauna and flora of EU interest. Member countries of the European Union, thus, should study and regularly survey these species, and their habitat requirements should be known. *Dioszeghyana schmidtii* (Lepidoptera: Noctuidae) is listed in ANNEX II (animal and plant species of EU interest, whose conservation requires the designation of special conservation areas) and in ANNEX IV (animal and plant species of EU interest in need of strict protection) of the directive.

The imagines of this species occur in March to May (Fajčík 1998; Nowacki 1998; Korompai 2006), especially so in the second half of April. The flight period is usually short (Ronkay et al. 2001). Larvae are to be found May to June (Fajčík 1998, personal observation). Known larval food-plants include: *Quercus* spp. (König 1971; Fajčík 1998; Marek personal observation), as well as, *Acer tataricum* (Nowacki 1998; Ronkay et al. 2001). Rákosy (1996) reported *Acer*, in addition to *Quercus* species, as food-plants. According to Korompai (2006), the main larval food-plants are: *Acer tatari-*

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cum and *A. campestre.* However, in larval ecology and in larval food-plants are still some doubts. In terms of habitat preferences; *D. schmidtii* is to be found in xerothermic forests and forest-steppes, it also occurs in managed forests (Korompai 2006). The species is reported from Hungary, southern Slovakia, Romania, Bulgaria, northern Greece and Turkey (central Anatolia) (Ronkay et al. 2001). The species' distribution has been intensively studied in Hungary in recent years (cf. Korompai, Kozma 2004; Korompai 2006; Szabó et al. 2007). Since the species has also been taken in south-western Slovakia close to the border with Austria and the Czech Republic, it is safe to assume that *D. schmidtii* also occurs in the frontier zones of those two latter countries.

This species has been recorded mainly from light traps (König 1971; Korompai, Kozma 2004; Korompai 2006; Szabó et al. 2007). Imagines of *D. schmidtii* are rather similar to related species, of the genus *Orthosia* (e.g. *O. cruda*), its specific external characters (habitus), and/or pictures, are often published in the bibliography (Rákosy 1996; Fajčík 1998; Nowacki 1998; Ronkay et al. 2001; Korompai 2006). In contrast, *D. schmidtii* larvae have been studied only rarely. A detailed description of the larva (Turkish stock) was published (Beck 1999a,b; 2000a,b), in addition, descriptions of younger larval instars were put together by König (1971). Identification keys to establish the most salient larval characteristics of *D. schmidtii*, and at the same time, distinguish it from similar species in the field, has yet to be published.

Imagines of *Orthosia* s.l. need food prior to oviposition and pairing. They are relatively long-lived (Patočka 1950) and fly to nectar sources provided essentially by willow catkins (*Salix* spp.) which are blooming in early spring (Patočka 1950). So, if observations to date have been facilitated by light-trap-caught moths, it must be emphasized that where light traps are placed does not necessarily mean that the moths' usual habitat coincides with where they were taken in such traps (those two habitats may be completely different), if we consider that the moths are highly mobile, it is necessary to be more precise in order to determine the habitats where the species lives, and in so doing, protect the self-same habitats. For this reason, it is imperative to study and survey larvae, and not only adults. The results of such studies allow a better guarantee of protection of this species' habitats, and it alone.

We describe the larval characteristics of *D. schmidtii* in this paper, which can be used in order to separate this species from similar larvae which may live in similar habitats at the same time of year. We also present a simple recording and survey method for this species in its larval stage, together with the advantages of such.

MATERIAL AND METHODS

To obtain *D. schmidtii* larvae it is recommended to simply beat the bottom branches of the food-plant up to 3 m above ground level. The larvae of this species, like related species of the genus *Orthosia* Ochsenheimer, 1816, are to be found mainly on individual trees which are not necessarily tall, and may, or may not be bushy, growing on edges of forest stands (or on branches of solitary trees in forest-steppes). We have recorded this species in southern Slovakia by beating larvae from the bottom branches of *Quercus cerris* and *Q. pubescens* in the years 2002–2004 and also in 2007–2008. We have never recorded this species on either *Acer tataricum* or *A. campestre*, in spite of the fact we have focused on these trees, which are included as larval food-plants. The occurrence of *D. schmidtii* in the northern part of its distributional area it would be expected in the following habitats defined by Natura 2000: 91G0 Pannonic woods with both *Quercus petraea* and *Carpinus betulus*; 91H0 Pannonian woods with *Quercus pubescens*; 91I0 Euro-Siberian steppic woods with *Quercus* spp., and 91M0 Pannonian-Balkanic Turkey Oak-Sessile Oak forests (Viceníková, Polák 2003). The I. instar larvae are very similar to other related noctuid species; the II. instar larva already has typical external features (König 1971), such characteristics are visible well up to the V. instar. This means in practice, that larvae longer than 5 mm are possible to identify in the wild, but an optimal length would be over 10 mm, when it is not necessary to use a magnifying glass. The optimal time for survey and identification of larvae is the second half of May until the first half of June. This period is defined phenologically in the following terms: the end of *Malus* spp. and *Crataegus* spp. blossoming up to the flowering of *Rosa canina* and *Tilia cordata*.

Larvae of *D. schmidtii* are often accompanied on oaks, maples and hornbean by other larvae of several Lepidopterids (as well as larvae of Hymenoptera: Symphyta; Tenthredinidae), which are more-or-less similar to *D. schmidtii*. The identification key we have put together allows one to identify larva of *D. schmidtii*, and separate it from more-or-less similar larvae which are of ochre, reddish, brown or black in colour, or else are cryptic.

RESULTS

Identification of larvae

1 Larva with 2–5 pairs of abdominal legs and 5 pairs of stemmata on sides of head (Lepidoptera larvae) ..... 2.
– Larva with more than 5 pairs of abdominal legs and with 1 stemma on sides of head ..... larvae of Tenthredinidae.

2 (1) Larva with 5 pairs of fully-developed abdominal legs, each with longitudinal row of hooks. Dorsally with only individual, often inconspicuous setae (naked larvae)..... 3.
– Larva with either dwarf frontal pairs of abdominal legs, these ones shorter than two caudal pairs or with these legs absent; abdominal leg-hooks sit transversally or in a circle, or there are more rows of hooks. Larva may have long setae (hairy larvae) ..... (larvae of other Lepidoptera).

3(2) Abdominal leg-hooks the same length. Legs with maximally 3 setae. Cylindrical body-shape, without conspicuous tubercles larvae of noctuids (subfamily Hadeninae) ..... 4.
– Abdominal leg-hooks alternately shorter and longer, or pro-legs with more than three setae, or body shape is not cylindrical, body may have conspicuous tubercles ..... larvae of other Lepidoptera.

4(3) Laterally with strongly undulate bright stripe, dorsal line with bright prominences upper and dark ones lower; pinacula at the base of setae massive, large and dark. Similar rounded dark spots also on head ..... 5.
– Laterally with strongly undulate bright stripe, or other similar pattern, the pinacula at the base of the setae are small and often bright. The body may have dark spots and other patterns; these are not pinacula at the base of the setae, however. Cephalic capsule with usually dark and bright marbling or net-like pattern, sometimes, with more conspicuous dark stripe, or monochromatic bright or dark, without bigger rounded spots ..... 6.

5(4) Dorsally brownish-grey, only dorsal line narrower and brighter, rather inconspicuous. Margin between dorsum and lateral stripe strongly undulated ..... *Dioszeghyana schmidtii* (Diószeghy 1935) (Figs. 1–4).
– Dorsally blueish-grey (blueish-grey brown), dorsal line wide, shiny yellow to orange. Margin between dorsum and lateral stripe only weakly undulated ..... *Orthosia miniosa* (Denis & Schiffermüller, 1775) (Fig. 5). **Living on oaks mainly, young larvae gregarious in tents**

6(4) Lines dorsally and laterally formed by longitudinal rows of conspicuous white spots. Colouration dark reddish-brown to blackish-brown ..... *Dicycla oo* (Linnaeus 1758) (Fig. 6). **Living on oaks, often among spun-leaves**
– Dorsally, and often also laterally line less conspicuous, or formed by continuous, not interrupted stripe. If laterally line with white spots, absent on dorsal line ..... 7.

7(6) Laterally line with white spots, these bigger and more conspicuous frontally and prior to the caudal end. Dorsally line mostly narrow and inconspicuous, similarly subdorsally, which is more conspicuous as white on black pro-thoracic dorsal sclerotized plate (shield). Colour brown-black to black ..... *Eupsilia transversa* (Hufnagel 1821) (Fig. 7). **Living polyphageously on broadleaved trees and herbs**
– Laterally line locally bigger spots absent or body coloration distinct ..... 8.

8(7) Laterally line, at least in central part, with conspicuous undulation dorsally, this undulation yellowish-white to yellow in colour. Area above lateral line lacks dark stripe ..... 9.
– Laterally line with inconspicuous undulation dorsally, or undulation absent. If undulation present, this more conspicuous, dark stripe above lateral line present ..... 10.

9(8) Laterally line uninterrupted, forming rounded undulations, steeper frontally than caudally ..... *Dryobota labecula* (Esper 1788). **Southern European species feeding on oaks**
– Laterally line on border of undulations narrowed or interrupted. Undulation present centrally only and these often bilobal ..... *Rileyiana fovea* (Treitschke 1825) (Fig. 8).**Very local and rare in Central Europe, living on oaks**

10(8) Pinacula relatively small and dark. Microsculpture robust (visible on 20× magnification) thorn-like. Colouration variable, brown, darkish-grey or greenish. Prothoracic dorsal sclerotized plate often darker than in its vicinity ..... *Orthosia cruda* (Denis & Schiffermüller 1775) (Fig. 9). **Host plants mainly oaks, also hornbean, maples, and other broadleaved trees**
– Pinacula bright, darkly bordered or inconspicous. Microsculpture fine, formed by nipples or papilae ..... 11.

11(10) Caudally margin of abdominal segment 8 below dorsum (behind pinaculum D2; chetotaxy

Fig. 1. Larva of *D. schmidtii* (photo: Turčáni); Fig. 2. Freshly moulted larva of *D. schmidtii* (photo: Turčáni); Fig. 3. Black spots on head of *D. schmidtii* are invisible after ecdysis (photo: Turčáni); Fig. 4. Larva of *D. schmidtii* use old bud scales as shelter (photo: Turčáni); Fig. 5. Larva of *Orthosia miniosa* (photo: Kulfan); Fig. 6. Larva of *Dicycla oo* (photo: Kulfan); Fig. 7. Larva of *Eupsilia transversa* (photo: Kulfan); Fig. 8. Larva of *Rileyiana fovea* (photo: Turčáni)

Fig. 9. Larva of *Orthosia cruda* (photo: Turčáni); Fig. 10. Larva of *Jodia croceago* (photo: Turčáni); Fig. 11. Larva of *Mesogona acetosellae* (photo: Kulfan); Fig. 12. Larva of *Conistra vaccinii* (photo: Kulfan); Fig. 13. Larva of *Agrochola* sp. (photo: Turčáni); Fig. 14. Larva of *Anorthoa munda* (photo: Turčáni); Fig. 15. Larva of *Tiliacea sulphurago* (photo: Turčáni); Fig. 16. Larva of *Scotochrosta pulla* (photo: Turčáni)

according to McGuffin 1967) conspicuous, relatively big, white, bordered dark frontally. Larva bright ochre, with fine web-like pattern and with dark angular patterns on dorsum ..... *Jodia croceago* (Denis & Schiffermüller 1775) (Fig. 10). **Living on oaks**

– Larva without similar spots at the end of dorsum of abdominal segment 8. Colouration and patterns different ..... 12.

12(11) Larva uniformly coloured dorsally, especially if finely spotted or marbled, usually grey to reddish-brown ..... 13.

– Larva with conspicuous dark spots, stripes or marbelled dorsally. Coloration often greyish-black, grey, yellowish-grey or reddish-brown ..... 15.

13(12) Larva with elevated and conspicuously bright dorsal pinacula. Cephallic capsule relatively big, lateral line inconspicous ..... *Mesogona acetosellae* (Denis & Schiffermüller 1775) (Fig. 11). **Living on oaks and other woody plants**

– Larva with inconspicuous pinacula. Cephallic capsule relatively small ..... 14.

14(12) Laterally line inconspicuous usually, pro-thoracic dorsal sclerotized plate dark, mainly laterally, almost black, sub-dorsal line very conspicuous in constrast, white ..... *Conistra* Hübner 1829 (Fig. 12). **V. instar larvae of this genus often migrate to undergrowth.** The most abundant species **which feed on oaks and maples in earlier instars are** *C. vaccinii* (Linnaeus 1761) (Fig. 12) and *C. erythrocephala* (Denis & Schiffermüller 1775).

– Laterally line inconspicuous, pro-thoracic dorsal sclerotized plate also inconspicuous, similar in colour in vicinity. Cephallic capsule black.... *Spudea ruticilla* (Esper 1791). **Living on oaks, very local and rare in Central Europe**

– Laterally line visible often conspicuous and bright. Thoracic scutum inconspicuous or reddish-brown usually, with white dorsally and subdorsally. Cephallic capsule reddish-brown..... *Agrochola* Hübner 1821 (Fig. 13). *A. laevis* (Hübner 1803) **on oaks mainly;** *A. helvola* (Linnaeus 1758) in contrast is **polyphagous.** *A. laevis* black spiracles; *A. helvola* white spiracles, laterally line more conspicuous, white.

15(13) Dark (often black) line present above lateral line, line enlarged on abdominal segment 8, often the left and right line almost merge in the centre of dorsum. Abdominal segment 8 is often a little domed at dorsum. Cephallic capsule reddish-brown, dark web-like pattern..... *Anorthoa munda* (Denis & Schiffermüller 1775) (Fig. 14). **Living polyphagously on broadleaved trees**

– Black narrow line present above lateral line, or larva lacks dark line above lateral line. If present, not enlarged on abdominal segment 8, segment is not visibly elevated ..... 16.

16(15) Abdominal segments 1–8 with dark shovel-like spots below dorsum, spots with bright pinacula of dorsalsetae (D1 and D2) ..... *Dichonia* Hübner 1821. *D. convergens* (Denis & Schiffermüller 1775) white-grey on dorsum with brownish-black spots. *D. aeruginea* (Hübner 1808) with ferrous spots. **Both species on oaks.**

– Dorsum of abdominal segments 1–8 without dark shovel-like spots. Dorsum at abdomen often with rhomboid or oblique dark patterns, marbled ..... 17.

17(16) Dorsum relatively bright, ochre, or greyish-brown, with bright dark brown pattern. Bright lateral line wide, conspicuous, with lobes dorsally ..... *Tiliacea sulphurago* (Denis & Schiffermüller 1775) (Fig. 15) **Larva short and stout, on maples, mainly on *Acer campestre***

– Dorsum grey to dark grey with bright and dark pattens. Laterally line without conspicuous projections ..... 18.

18(17) Dorsum; rhomboid spotting. Larva usually lack more conspicuous dark stripe above lateral line. Larva up to 45 mm in length ..... *Griposia aprilina* (Linnaeus 1758). **Living mainly on oaks**

– Dorsum, above subdorsal with large, black triangular spotting. Conspicuous and undulate black stripe above lateral line. Larva up to 35 mm of length ..... *Scotochrosta pulla* (Denis & Schiffermüller 1775) (Fig. 16). **Larva on oaks.** Similar to south European species in genus *Dryobotodes* Warren 1911: *D. roboris* (Boisduval 1828), *D. carbonis* (Wagner 1931) and *D. tenebrosa* (Esper 1789). **All on oaks.**

Description of larva

Larval description: *O. schmidtii* (based on 10 individuals from southern Slovakia); body 20–30 mm in length, only little narrower forward and from the body centre to abdominal segment 9 almost same in width (Fig. 1). Medium size bright cephallic capsule; large black spots, invisible after ecdysis (Fig. 3). Dorsum grey-brown with brighter marbelling, only caudal end (from abdominal segment 9) is brighter.

Darker longitudinal stripes sometimes present below dorsum. Sclerotized plate on dorsum of thoracic segment 1 inconspicuous, same colour in vicinity. Setae relatively conspicuous; basal areas (pinacula) forming large black rounded spots; conspicuous also on darker dorsum (Figs. 1, 2, 4). Dorsally abdominal segment 8 usually darker. Wide lateral stripe; conspicuously bright, whitish-yellow to pink; towards dark dorsum deeply undulated, thus bright; dark lobes in contrast. These lobes with big dark spot. Lateral line vivid colouration reaches to claspers. Pro-legs bright in colour.

The most similar larva to *D. schmidtii* is probably the caterpillar of *Orthosia miniosa*, which feeds on oaks especially. It addition has big black rounded spots on head and on dorsum. The colouration of dorsum is slate-grey; lines dorsally and subdorsally, which are visible also on head, are yellow to orange (Fig. 5). Dorsum at caudal end is inconspicuous. Border between bright lateral line and dark dorsum is only slightly undulated. Additional species of this genus e.g. *Orthosia cruda* feeds on oaks and hornbean, does not have big black spots on head (Fig. 9), its head is often completely black. The absence of big black spots, is not to be confused with the presence of small pinacula (Fig. 9). Margin between lateral and dorsum area is not undulated, and there is an absence of dark and bright lobes. This larva is conspicuously sculptured this being formed by dense tiny spines visible at 20× magnification.

DISCUSSION AND CONCLUSIONS

According to the aforementioned directive, ANNEX III (Criteria for selecting sites eligible for identification as sites of community importance and designation as special areas of conservation), "Site assessment criteria for a given species in ANNEX II" (Anonymous 1992) should adhere to the following procedure:

(A) Size and density of the population of the species present on the site in relation to the populations present within national territory.
(B) Degree of conservation of the features of the habitat which are important for the species concerned and restoration possibilities.
(C) Degree of isolation of the population present on the site in relation to the natural range of the species.
(D) Global assessment of the value of the site for conservation of the species concerned.

According to these principles, there is a basic need for the recording and the survey of *D. schmidtii*, the most appropriate recording stage which is connected directly with habitat (principle (B) above: includes data on the eggs, larvae and pupae). *D. schmidtii* is a protected species of EU interest and it should be monitored, if possible without damage to specimens. A subsequent request is that surveyed developmental stages must be easily observable in the wild in sufficient numbers. It is advantageous, if each such record provide additional information useful in order to protect the surveyed species.

Collecting the larvae from branches of host trees by using beating trays has several advantages

(1) One of the biggest advantages is that number of larvae (mainly immature stages) is higher than the number of adults. Larger datasets from higher number of study plots may allow statistical processing of the data.
(2) Field work is relatively independent on weather conditions. Inclement weather for this method would include rain and/or stronger winds.
(3) Beating of larvae allows identification of their distribution patterns even in relatively small areas of habitat, which would include the precise host tree. Due to different information about larval food-plants (König 1971; Rákosy 1996; Fajčík 1998; Ronkay et al. 2001; Korompai 2006) it is possible, that some *D. schmidtii* populations prefer more *Quercus*, and others *Acer*, not to mention also the possibility of *Carpinus*. Using beating trays, it is possible to exactly localize larvae on its food plant (up to 3 m from ground level; which is the space commonly accessible by beatings trays).
(4) Using one type of beating tray and sampling branches of fixed size, it is possible to collect comparable data, and estimate abundance of larvae in different study sites. Circle beating trays of 1 m diameter and the sampling of the terminal parts of branches 1 m in length brings quantitative data from these parts of the trees.
(5) After identification, it is possible to leave sampled larvae on the food-plant in the field.
(6) If necessary, it is also possible to study collected larvae in additional laboratory rearing, and estimate the parasitoid attack rate, and/or presence of pathogens, and eventually be able to survey additional parameters of population (larvae, pupae, adults).

The proposed methods have several disadvantages:

(1) The field work with beating tray is very time consuming, more so than the collecting of adults by light traps. However, it is efficient enough after enough practice.

(2) There are several similar species of larvae, but our identification key allows separation and identification of *D. schmidtii* directly in the field, and the most important data is available at once.
(3) It is necessary to take into account that the larvae of *D. schmidtii* have typical behaviour, when they often hide in the shelters below or amongst old bud scales (Fig. 4), or among spun leaves, and therefore we suggest exhaustive beating on surveyed trees.

This method of caterpillar collection, and also of other insect groups from trees by using the beating technique is regular and well-recognized. It has been used in various types of ecological studies (Basset et al. 1997; Campos et al. 2006; Kulfan et al. 2006; Hicks et al. 2007), often in relation to phytophage – host-tree. However, with light trapping, done by using of automatic light traps allows the obtaining of valuable information about adults (Wolda et al. 1992; Basset et al. 1997; Szentkirályi 2002; Raimondo et al. 2004; Spalding, Parsons 2004; Szabó et al. 2007; Hirao et al. 2008). Both methods may be combined in a survey and study of *D. schmidtii* populations at the same time:
(1) Survey the presence of adult taken in light traps.
(2) Survey of optimal habitats in several km vicinity from light traps with captures.
(3) Exact survey of populations by using the described beating technique and the identification key.

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